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CVD DEVICE
[CVD sochi]

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Claim

In a CVD device wherein a wafer is placed on a heating stage furnished in a reaction chamber and in which gas is supplied simultaneously as the aforementioned wafer is heated to produce a film on the aforementioned wafer, a CVD device characterized in being furnished with a gas feed head having many small holes furnished in a position facing the wafer and an infrared ray transmitting window furnished opposite the wafer for the gas feed head, and a radiation thermometer is furnished on the outside thereof.

Detailed explanation of the invention

[0001]

Industrial field of application

The present invention pertains to a CVD device that forms a metal film, metal silicide film, oxide film, nitride film, silicon film doped with impurities, etc., on a wafer surface in a semiconductor manufacturing process, and in particular, relates to a CVD device that can heat the wafer uniformly and rapidly and can easily measure the wafer temperature precisely, in a cold wall type device.

[0002]

Prior art

In previous CVD devices, a wafer was mounted on a heating stage, and with heating to a specified temperature, a reaction gas was supplied to form a film on the wafer surface. The structure was generally one in which a plate-like susceptor was heated by a heater or lamp, etc., heating the wafer placed on top of it. Control of the heating stage temperature was accomplished by a method wherein a thermocouple was pressed against the susceptor to measure the temperature and the amount of heat generated by the heater was controlled until it reached the set temperature. The actual wafer temperature was often not exactly

known, and calibrating with the susceptor temperature using a dummy wafer with a thermocouple and estimating the wafer temperature based on that, and other countermeasures were used. However, even when the susceptor temperature is constant, the wafer temperature sometimes changes for the reasons shown below. When a wafer with a different surface state from the dummy wafer is used, the actual temperature departs significantly from the dummy wafer because its radiation absorption rate or emissivity is different.

[0003]

As can be seen in Figure 7, even when the susceptor temperature is constant, the wafer temperature changes with pressure in the pressure range of 0.01-100 Torr, which is the most frequently used in the CVD process. This is caused by thermal transmission through gas between the back of the wafer and the susceptor and is because the amount of heat transmitted to the wafer from the susceptor changes with changing processing pressure, since the thermal conductivity of a gas in the molecular flow region is proportional to pressure. Even when a gas with high thermal conductivity, such as He, is introduced between the back of the wafer and the susceptor to shorten heating time, the wafer temperature changes when the gas pressure changes.

[0004]

If a radiation thermometer is used to measure wafer temperature directly, these problems are eliminated. Broadly speaking, there are two methods for measuring wafer temperature using a radiation thermometer.

[0005]

In one method, measurement is performed through the heater or lamp. Because radiation by the heat source is reflected by the back of the wafer and measured with a radiation thermometer, the problem is that the wafer temperature cannot be measured exactly. A wafer handling mechanism, cooling structure, etc., must also be incorporated inside the heating stage in addition to the heater, so the space to mount a radiation thermometer is often limited. This is why devices that measure only one point are common for measuring wafer temperatures.

[0006]

In another method, the transmitting window is exposed to reaction gas, a film is deposited on the inside, and infrared ray transmissivity changes over time. For this reason, the infrared ray intensity measured by the radiation thermometer gradually decreases, with the problem that the measured temperature will be lower than the actual temperature. To handle this, a structure has been proposed to blow inert gas from the periphery so that the reaction gas will not touch the infrared ray transmitting window. However, the inert gas flow affects the reaction gas flow, diminishing the uniformity of film formation. In addition, the structure to supply inert gas is complicated, and because inert gas must always be supplied during film formation, a large amount of gas is consumed.

[0007]

Problems to be solved by the invention

The present invention solves the aforementioned problems in the prior art in CVD devices and provides a structure with which the distribution of the wafer temperature can easily be measured.

[0008]

Means to solve the problems

To solve the aforementioned problems, the present invention is characterized in having a gas feed head facing the wafer, a gas introduction opening in the gas feed head, at least one radiation thermometer disposed to measure the wafer through the gas introduction opening, and an infrared ray transmitting window between the radiation thermometer and the gas feed head.

[0009]

Function

Infrared rays radiated from the wafer pass through the gas introduction opening in the gas feed head to be received by the radiation thermometer, and the wafer temperature is measured. During film formation, because reaction gas is always supplied from the gas introduction opening, reaction products can be prevented from flowing back to the feed head and adhering to the infrared ray transmitting window by this flow of gas. Therefore, the infrared ray transmitting window is always kept at constant transmissivity, improving the precision of temperature measurement by the radiation thermometer.

[0010]

Application example

A cross section of a CVD device which is a first application example of the present invention is shown in Figure 1. A heating stage (2) is furnished inside reaction chamber (7), a wafer (1) is placed on it with the surface facing up, and reaction gas (13) is fed in the form of a shower from multiple gas introduction openings (14) furnished in a gas feed head (6) that faces it. Multiple types of reaction gas are fed to gas feed head (6) from the outside by gas pipes (16) and (17), they mix inside, and are fed to wafer (1).

Reaction chamber (7) is lowered to a specified pressure by a vacuum pump (not shown). A heater (3) is incorporated into heating stage (2) and wafer (1) is heated through susceptor (4). Susceptor (4) is selected from dakufuaito [transliterated], SiC, SUS, Inconel, aluminum or other materials taking into consideration processing temperature, corrosion resistance, etc. The amount of radiation at the periphery of wafer (1) is larger than at the center, and the temperature will drop, so heater (3) has a structure divided into multiple [zones] (3-1, 3-2) that control temperature independently to make the temperature uniform. For example, when a one-zone heater 240 mm in diameter is used to process a 240 mm diameter wafer at 650ºC, the peripheral part of susceptor (4) will be about 40ºC lower than the center, as shown in Figure 4, and the periphery of wafer (1) will also be 40-50ºC higher than the center. Heater (3) is supported with a heater support part (9) with intervening thermal insulation material (11). Temperature control is performed by monitoring the temperature of susceptor (4) with a temperature sensor (15) and controlling the amount of heat generated by heater (3) using a temperature regulator (not shown) so that the measured value will be a specified temperature. A thermocouple or radiation thermometer is used as temperature sensor (15), and the same number of temperature sensors (15) and temperature regulators as the number into which heater (3) is divided is required. When heater (3) is divided into 2 zones, temperature sensors (15) are mounted so that the monitored positions are at the center of wafer (1) and at the wafer edge.

[0011]

Gas feed head (6) and reaction chamber (7) are cooled (not shown) in order for wafer (1) to be heated to a specified temperature and to prevent film formation except on wafer (1). In order to prevent radiation to the underside of heating stage (2) and prevent a rise in temperature, a water-cooling jacket (12) is furnished, and radiation shield plates (10) are additionally placed below heater (3). The number of radiation shield plates (10) varies according to how much the temperature on the underside of the heating

stage must be kept down, and 1-5 may be installed. For the material, that with high reflectivity, such as aluminum, is preferable. A gas introduction opening (14) to feed reaction gas is furnished in gas feed head (6) facing wafer (1), and an infrared ray transmitting window (8) is placed above it. A radiation thermometer (5) is furnished above it so that the wafer may be seen through gas introduction opening (4). When wafer (1) is loaded on the susceptor, its temperature is measured by radiation thermometer (5). Two radiation thermometers (5) are used in Figure 1, and the temperature of wafer (1) is measured at 2 locations – the center and the periphery.

[0012]

Figure 2 is a cross section showing a second application example of a CVD device. In place of multiple radiation thermometers, a radiation thermometer (5) affixed to a traverse apparatus (18) is used, and the temperature distribution at multiple points on wafer (1) is measured by moving radiation thermometer (5).

[0013]

Figure 3 is a cross section showing a third application example of a CVD device. In place of multiple radiation thermometers, a thermal camera that contains the entire wafer at one time in its visual field is used. For radiation thermometer (5), a camera that uses a CCD imaging element for the sensing element and that also uses an interference filter for a specified wavelength can be used (for example, 0.9 μm is satisfactory for a silicon wafer). Generally, a radiation thermal camera may be used of the type that uses a photoelectric type infrared sensor, such as HgCdTe or InSb, etc., and that obtains a thermal image by scanning with a mirror.

[0014]

During film formation, the set temperature of individual heaters (3-1) and (3-2) is changed with a temperature setting unit (not shown) based on the temperature distribution measured by radiation thermometer (5), and adjusted so that the temperature of wafer (1) will be uniform. As an example, the temperature change with wafer (1) mounted on susceptor (4) is shown in Figure 5. Heater (3) is divided into 2 zones, and the inside is 200 mm in diameter and the outside is 280 mm in diameter. The heaters for the two zones are controlled with the measured value from temperature sensor (15) so that the temperature of susceptor (4) will always be 670ºC. The temperature of wafer (1) is the value measured by radiation thermometer (5). First, it can be seen that the temperature of wafer (1) rises more at the periphery than in the center, the temperature rise of the periphery slows during the process and the temperature of the center rises. Based on this, the result of setting the target temperature of outside heater (3-2) 20ºC higher – 690ºC – than inside heater (3-1) after 60 seconds is as illustrated in Figure 6. As can be seen, the uniformity temperature improves in wafer (1). Thus, temperature uniformity can be improved by measuring the temperature distribution of wafer (1).

[0015]

Effects of the invention

With the present invention, wafer temperature distribution in a CVD device can be controlled easily and precisely, so control of a heater divided into multiple zones can be optimized, and the uniformity wafer temperatures can be improved. Because of this, the yield can be improved of the manufacturing processes of semiconductor elements.

Brief description of the figures

Figure 1 is a cross section showing the structure of a CVD device in a first application example of the present invention.

Figure 2 is a cross section showing the structure of a CVD device in a second application example of the present invention.

Figure 3 is a cross section showing the structure of a CVD device in a third application example of the present invention.

Figure 4 is a characteristics diagram showing wafer temperature distribution with a one-zone heater.

Figure 5 is a characteristics diagram showing wafer temperature change in a CVD device based on the first application example of the present invention.

Figure 6 is a characteristics diagram showing wafer temperature change when the heater control in a CVD device based on the first application example of the present invention is improved.

Figure 7 is a characteristics diagram showing an example of the relationship of wafer temperature and reaction chamber pressure in a CVD device.

Explanation of symbols

1 Wafer

2 Heating stage

3 Heater

4 Susceptor

5 Radiation thermometer

6 Gas feed head

7 Reaction chamber

8 Infrared ray transmitting window

9 Heater support part

10 Radiation shield

11 Thermal insulation material

12 Water-cooling jacket

13 Reaction gas

14 Reaction gas introduction opening

15 Temperature monitor

16, 17 Gas pipe

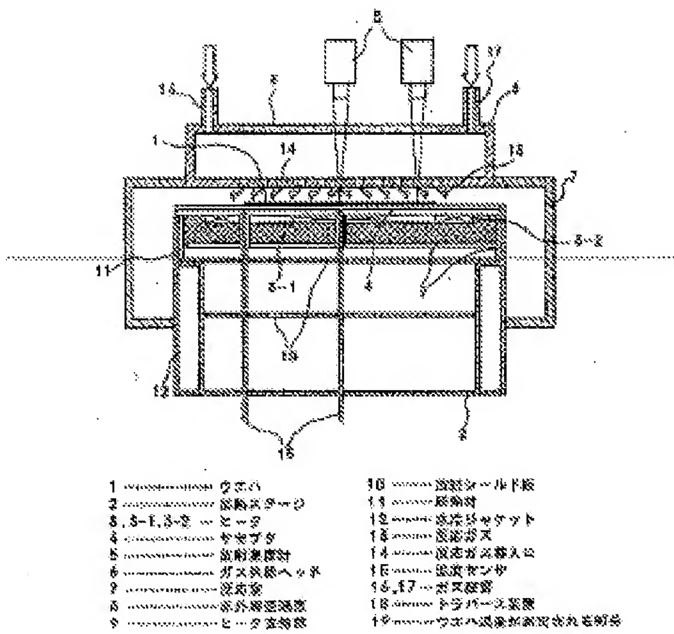

Figure 1

Legend: 1 Wafer

2 Heating stage

3 Heater

3-1 Heater

3-2 Heater

4 Susceptor

5 Radiation thermometer

6 Gas feed head

7 Reaction chamber

8 Infrared ray transmitting window

9 Heater support part

10 Radiation shield plate

11 Thermal insulation material

12 Water-cooling jacket

13 Reaction gas

14 Reaction gas introduction opening

15 Temperature sensor

16 Gas pipe

17 Gas pipe

18 Traverse apparatus

19 Portion at which wafer temperature is measured

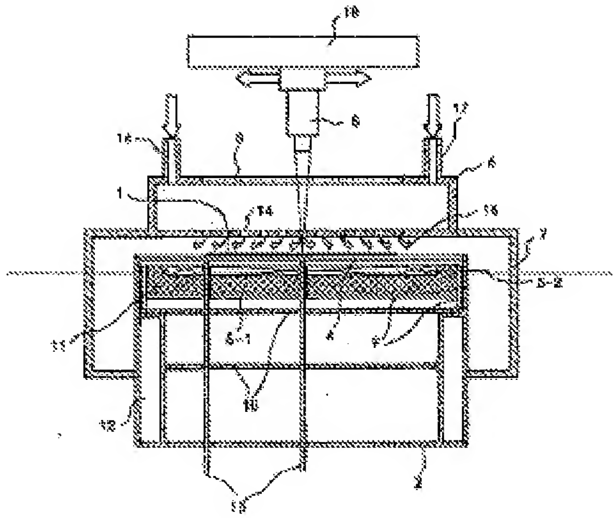

Figure 2

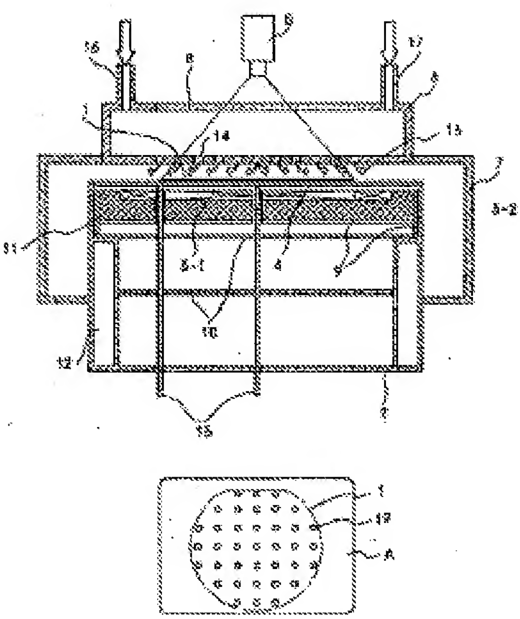

Figure 3

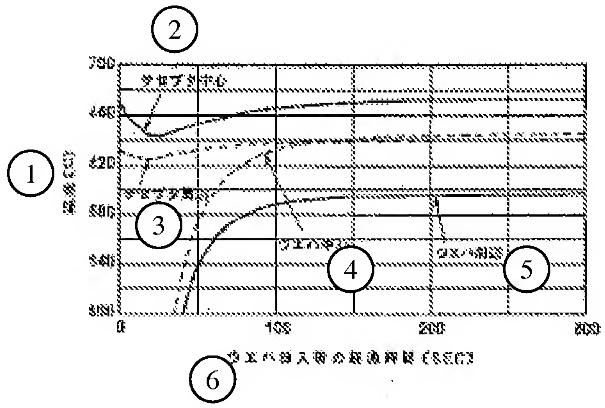

Figure 4

Key: 1 Temperature

2 Susceptor center

3 Susceptor periphery

4 Wafer center

5 Wafer periphery

6 Elapsed time after wafer insertion

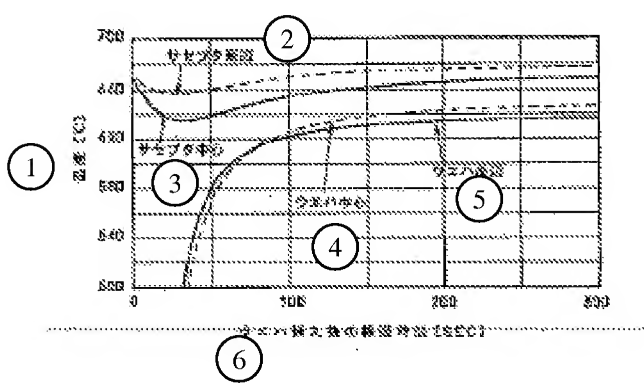

Figure 5

Key: 1 Temperature

2 Susceptor periphery

3 Susceptor center

4 Wafer center

5 Wafer periphery

6 Elapsed time after wafer insertion

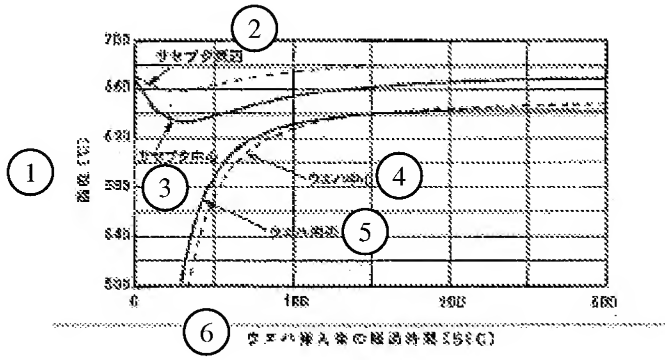

Figure 6

Key: 1 Temperature

2 Susceptor periphery

3 Susceptor center

4 Wafer center

5 Wafer periphery

6 Elapsed time after wafer insertion

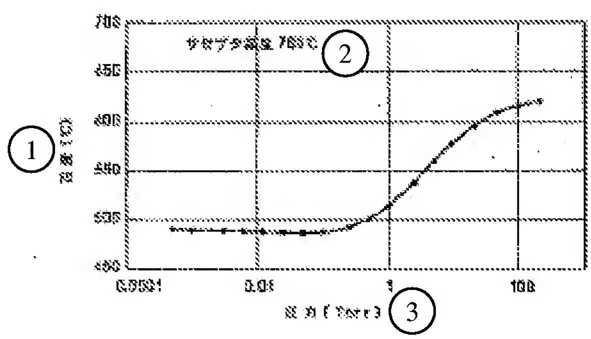

Figure 7

Key: 1 Temperature

2 Susceptor temperature

3 Pressure